HORIZON 2020

WORK PROGRAMME 2016 – 2017

Excellent Science

Future and Emerging Technologies

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Introduction

Future and Emerging Technologies activities help to create in Europe a fertile ground for responsible and dynamic multi-disciplinary collaborations on future and emerging technologies and for kick-starting new European research and innovation eco-systems around them. These will be the seeds for future industrial leadership and for tackling society's grand challenges in new ways.

FET focuses on research beyond what is known, accepted or widely adopted and supports novel and visionary thinking to open promising paths towards **radically new technological possibilities**. In particular, FET funds **interdisciplinary collaborations** that seek genuine cross-fertilisation and deep synergies between the broadest range of advanced sciences (including the life sciences, social sciences and humanities,…) and cutting-edge engineering disciplines.

FET has three main lines of activity:

> **FET Open** supports the early-stages of the science and technology research and innovation around new ideas towards radically new future technologies. It also funds coordination and support activities for such high-risk forward looking research to prosper in Europe.[1]
>
> **FET Proactive** addresses promising directions for research on future technologies in order to build up a European critical mass of knowledge and excellence around them.
>
> **FET Flagships** are science-driven, large-scale, multidisciplinary research initiatives oriented towards a unifying goal, aiming at transformational impacts with substantial benefits for European competitiveness and for society.

In this workprogramme, particular attention is paid to tapping into the **innovation** potential from the respective FET action lines. For example, actions to stimulate the exploitation of early results from FET research are foreseen. In order to create a wider and more diverse support base from which to take these innovations forward, the participation of new actors and of young and high-potential researchers and high-tech innovators is encouraged. Along the same line, FET pays attention to issues such as gender, age and culture, aware that this can offer new perspectives, pose new questions and open new areas of investigations.

Silo-breaking research collaborations in FET will improve readiness across Europe to take up **new research and innovation practices** that make leading-edge research more open, creative and closer to society, for example through 'open science' and the use of advanced simulation and open collaboration platforms. A variety of creativity-enhancing and artistic practices can be linked into research and innovation approaches, for instance for exploring technological visions, for testing unexpected technical solutions, developing novel uses of technology or for exploring their social acceptance.

[1] Note that 40% of the H2020 budget for FET is earmarked for FET Open.

FET research is well placed for **global collaborations** that can raise the level of excellence and accelerate the impact from global alliances. Thus, participation of excellent non EU partners in FET activities, whenever necessary and essential, is welcome.

The projects funded under this area will participate in the **Pilot on Open Research Data in Horizon 2020** in line with the Commission's policy on open research data.

Call FET-Open - novel ideas for radically new technologies

This call aims to support the early stages of joint science and technology research for radically new future technological possibilities. It is entirely non-prescriptive with regards to the nature or purpose of the technologies that are envisaged and thus targets mainly the unexpected. A bottom-up selection process will build up a diverse portfolio of projects. In order to identify and seize opportunities of long-term benefit for citizens, the economy and society, the early detection of promising new areas, developments and trends, wherever they come from, will be essential. The call also seeks for coordination and support activities to turn Europe into the best place in the world for responsible collaborative research and innovation on future and emerging technologies that will make a difference for society in the decades to come.

Proposals are invited against the following topics:

FETOPEN 1 – 2016/2017: FET-Open research projects

Specific challenge: The successful exploration of new foundations for radically new future technologies requires supporting a large set of early stage, high risk visionary science and technology research projects to test new ideas. Here agile, risk-friendly and highly interdisciplinary research approaches are needed with collaborations that expand well beyond the strictly technological disciplines. The renewal of ideas is complemented by the renewal of actors taking them forward. Therefore, this topic encourages the driving role of new high-potential actors in research and innovation, such as excellent young researchers and high-tech SMEs that may become the scientific and industrial leaders of the future.

Scope: This topic supports the early stages of research to establish a new technological possibility. Proposals are sought for collaborative research with all of the following characteristics:

- **Long-term vision**: the research proposed must address a new, original or radical long-term vision of technology-enabled possibilities that are far beyond the state of the art and currently not anticipated by technology roadmaps.
- **Breakthrough S&T target**: research must target a scientifically ambitious and technologically concrete breakthrough, argued to be a crucial step towards achieving the long-term vision and plausibly attainable within the life-time of the project.

- **Novelty**: the research proposed for achieving the breakthrough must find its plausibility in new knowledge, ideas and concepts, rather than in the mere application or incremental refinement of existing ones.
- **Foundational**: the breakthroughs that are envisaged must be foundational in the sense that they will establish a crucial basis for a new line of technology and its uses, not currently anticipated.
- **High-risk**: the inherently high risk will be reflected in flexible approaches to explore alternative directions driven by cutting-edge science and supported by agile research and innovation practices.
- **Interdisciplinary**: the proposed collaborations should go beyond current mainstream multi-disciplinary 'pipeline' configurations in joint science- and technology research and seek genuine exchanges, mutual learning, cross-fertilisation and synergistic advances among the disciplines involved to establish new areas and directions for joint explorations.

Expected impact:

- Initiating or consolidating a baseline of feasibility and innovation potential for a radically new line of technology and its future uses by establishing the essential proofs-of-principle and scientific underpinnings.
- European thought-leadership on new and emerging technologies, beyond academic excellence and carried forward also by new high-potential actors such as young researchers and high-tech SMEs that may become the European scientific and technological leaders and innovators of the future.
- Impact is also sought in terms of the take up of new research and innovation practices for making leading-edge science and technology research more open, collaborative, creative and closer to society.

Type of instrument(s): Research and Innovation Actions. The Commission considers that proposals requesting a contribution from the EU of between EUR 2 and 4 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Budget per type of instrument: 83M€ in 2016 and 110M€ in 2017, 2 deadlines per year.

The conditions related to this topic are provided at the end of this call and in the General Annexes.

FETOPEN 2 – 2016/2017: FET-Open Coordination and Support Actions

Specific challenge: The challenge is to make Europe the best place in the world for collaborative research and innovation on future and emerging technologies that will renew the

basis for future European competitiveness and growth, and that will make a difference for society in the decades to come.

Scope: Proposals shall address one of the following topics:

a) FET Futures [2017]: identifying strategy options, challenges and opportunities to stimulate and organise interdisciplinary research and innovation towards new and visionary technologies of any kind. Actions should combine evidence from FET (e.g., portfolio, constituency, results) and other sources (including other funding bodies or private initiatives worldwide, like those using prize schemes or challenges). They should aim at open and dynamic stakeholder participation using advanced methods and on-line tools/social networks.

b) FET Communication [2016-2017]: raising the visibility of FET and its potential impact towards various stakeholders well beyond the research communities through targeted activities and events. This may include collecting, aggregating and disseminating information from the entire range of FET projects and activities, and using an appropriate mix of channels and formats to engage with the target audiences, including policy makers and the public at large.

c) FET Exchange [2016-2017]: actions for structuring an emerging FET-relevant topic and the interdisciplinary communities around it. This shall include research roadmapping, stimulating learning and exchange, involving an appropriate range of disciplines (including the life sciences and humanities where relevant) and actors such as young researchers, entrepreneurs and high-tech SMEs, and broader stakeholder engagement. One specific theme to be addressed is the area of alternative metrics (so-called "altmetrics") to assess research outputs and researchers.

d) FET Conference [2016]: supporting the organisation of the fourth European Future Technologies Conference and Exhibition (see for example http://www.fet11.eu/). The conference shall showcase progress and results from FET research, seed new ideas across disciplines, foster a dialogue between science, policy and society on future and emerging technologies, explore new ways of combining research and innovation and involve high-potential actors that will make the difference. Proposals will address pre-conference communication, the local organisation, participant assistance and post-conference follow-up. The event shall take place early 2018.

e) FET Innovation Greenhouse [2016-2017]: actions towards a Europe-wide capacity for innovation, exploitation and entrepreneurship from visionary, high-risk interdisciplinary science and technology research such as that supported by FET. The focus should be on enabling the earlier creative and learning stages of innovation from FET research where the classical path of business models and business plans is still premature, many options still open and more agile and tailored approaches are needed. A wide technological scope, specificity to FET and complementarity with existing initiatives and services are of prime importance. Support to the actions funded under the FET Innovation Launchpad (FETOPEN 3) and for networking and exchange among them are also welcome.

For each of the scope items a) and d) at most one proposal will be funded.

Expected impact:

- European thought-leadership on new and emerging technologies with a strong engagement of scientists, citizens, innovators and policy makers.
- Improved long-term innovation potential in Europe both from the abundance of novel ideas and the range of actors ready to take them forward.
- Improved understanding of impact mechanisms for long-term science and technology research.
- Improved readiness across Europe to engage in silo-breaking research collaboration and to take up new research and innovation practices.

Type of instrument(s): Coordination and Support Actions. The Commission considers that proposals requesting a contribution from the EU of between EUR 0,3 and 0,5 million for scope items a), b) and c),, and up to EUR 1 million for the scope items d) and e), would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Budget per instrument: 4Meuro (2016) / 2MEuro (2017)

The conditions related to this topic are provided at the end of this call and in the General Annexes.

FETOPEN 3 – 2016/2017: FET Innovation Launchpad

Specific challenge: FET projects often generate new and unexpected opportunities for commercial or societal application. This topic aims at funding further innovation related work (i.e. activities which were not scheduled to be funded by the original project) to verify and substantiate the innovation potential of ideas arising from FET funded projects.

Scope: short and focused actions to take out of the lab a promising result or proof-of-concept that originated from within a FET project and to get it on the way to economic or social innovation through new entrepreneurship or otherwise. The action will support the transformation of a specific research result into a credible offering for economic or social impact, by exploring the feasibility of an exploitation path and by coordinating and supporting the assembling of the right knowledge, skills and resources and thus serves as a launch pad for exploitation.
This call is focused on the early innovation stages from result of an ongoing or recently finished project[2] funded through FET under FP7 or H2020. The link with the relevant FET project results is to be demonstrated in the proposal. Note that this call does not fund additional research, nor does it fund activities that are/were already foreseen in the relevant

[2] Project end date at most one year before the deadline of submission.

FET project. Activities to be funded should be fit-for-purpose (e.g., tailored to the level of maturity of the result to be taken up) and can include, among others, the definition of a commercialisation process to be followed, market and competitiveness analysis, technology assessement, consolidation of an IPR position and strategy, scenario and business case development.
By focusing on the very early stage of the innovation path where an SME may not yet exist, the scope of this call complements innovation through existing SMEs that could be funded under the ODI or SME schemes.

Expected Impact

- Increased innovation potential from FET projects by picking up expected as well as non-anticipated innovation opportunities.
- Creation of concrete high-potential innovations from FET projects.
- Stimulating, supporting and rewarding an entrepreneurial mind set in the research world.
- Seeding growth and the creation of jobs from FET research.

Instrument(s): CSA. The Commission considers that proposals for actions no longer than 18 months and requesting a contribution from the EU of up to 100KEuro would allow this specific challenge to be addressed appropriately.

Budget per instrument(s): 3MEuro from 2017 budget (2 deadlines, first late 2016)

The conditions related to this topic are provided at the end of this call and in the General Annexes.

Call FET Proactive – boosting emerging technologies

FET 2.1 – 2016: FET-Proactive: emerging themes and communities

Specific Challenge: to mature a number of novel areas and themes by working towards structuring emerging communities and supporting the design and development of transformative research themes. The main benefits of this structuring yet explorative approach are emerging novel areas that are not yet ready for inclusion in industry research roadmaps, and building up and structuring of new interdisciplinary research communities around them. It makes the step from collaborations between a small number of researchers, to larger collaborations addressing various aspects of a novel research theme to jointly explore possibilities for, and long-term implications of future technologies that matter.

Scope: proposals shall address research and innovation activities, aimed at jointly exploring directions and options to establish a solid baseline of knowledge and skills, and to foster the

emergence of a broader innovation ecosystem for a new technology in one of the following areas and more specific themes:

Area 1: Future technologies for societal change

a) Being human in a technological world: critical interdisciplinary explorations of potentially game-changing impacts of future technologies on humanity, in plausible as well as in extreme scenarios. This can include individual, gender, organisational, economical, cultural and societal impacts, for instance from changes to self- or social perception, to our narratives, or to human development (e.g., cognitive, physical) or evolution. Visions being addressed should be radically forward looking and relatively unexplored, such as hyperconnectivity, human augmentation, hybridisation of nature, life extension, extra-sensorial perception or real/virtual blending. The work should provide fresh perspectives that challenge current thinking, possibly influence research agendas, formulate concrete options for shaping a worthwhile and responsible future.
b) New science for a globalised world: tools and methods for the collaborative study, projection and engineering of large scale open socio-technological and –ecological systems characterised by complexity and inherent uncertainty due to, among others, partial knowledge and the participation of irrational actors. This includes topics such as Global Systems Science as a new integrative science approach, the emergence of global solutions as patchworks of local ones, non-rationality, the dynamics of social and cultural divides, of peace and conflict, and various incentives, drivers and enablers of change and innovation, including the arts.

Area 2: Biotech for better life

c) Intra- and inter-cell bio-nano-chem technologies: new approaches to enable the study and the engineering of processes within biological cells, as well as their interactions with purposes such as sensing, signalling, imaging, regulating, curing or for engineering the in- and inter-cell physics and processes. This can include natural cells, synthetic ones or combinations of these. Multiscale modelling and simulation of in-cell physical and chemical processes are included.
d) Bio-electronic medicines and therapies: using adaptive nerve stimulation for precise regulatory control of organs or other biological processes inside the human body, in order to restore or maintain healthy conditions. This includes bio-electronic medicines, medicine-free therapies, closed-loop BCI or more invasive stimulation, all within a setting of personalised medicine and theragnostics.
e) Cognitive neuro-technologies: Integrated approaches combining theory and technology-based experiments for understanding the circuits and pathways of cognitive functions (e.g., navigation, perceptually guided goal-oriented behaviour, motivation and reward, memory, knowledge and belief formation, reasoning and decision making, emotion, interaction, communication) and the related principles of neural coding and operation within and between brain regions. Proposals should focus on non-validated, leading-edge technologies that could be specifically relevant to cognitive neuroscience. Applications could include adaptive brain interfaces and

neuro-prosthetics to restore or support cognitive functions, exploiting the better understanding of brain activity, neuronal encoding and organisation of cognitive processes.

Area 3: Disruptive information technologies

f) New computing paradigms and their technologies: new foundations for computing, including bio-, nature- and socio-inspired ones that can encompass also aspects of communication and interaction, as well as non-technological aspects like organisation of physical/virtual space, and tailored to future and emerging challenges and requirements in highly interdisciplinary settings.

g) Quantum engineering: reproducible, economical and scaleable approaches, strategies and techniques for realising devices and systems that exploit quantum phenomena, such as superposition and entanglement, for achieving specific functionalities (for instance sensing, precision measurement, transduction, communication, control, simulation and computation) and possibly in the context of specific application areas (for example in the biological, medical, materials, process, energy or standards domain).

h) Hybrid opto-electro-mechanical devices at the nano-scale: new working principles and their first-time validation in nano-, molecular- or atomic-scale devices based on the interaction and mutual control of multiple physical degrees of freedom to achieve new or radically improved functionalities and application scenarios under plausible operating conditions. The interacting degrees of freedom are those involved in e.g. nano-optics, nano-scale electromagnetism, nano-mechanics and phonons and fluctuations.

Area 4: New technologies for energy and materials

i) Ecosystem engineering:[3] new models, materials and processes for extreme resource efficiency into artificial ecosystems (energy, raw materials, waste, water,…). New approaches and technologies for extremely efficient energy generation (e.g., artificial photosynthesis), transfer, conversion and storage. First time validation and assessment of these results in the context of integrated circular economy solutions or other quasi self-sufficient systems.

j) Complex bottom-up construction: self-organisation, assembly and adaptation of materials and physical systems with complex functionality, composition and/or spanning a range of scales (nano, meso).

When appropriate, this call topic allows for proposals to provide financial support to third parties in line with the conditions set out in Part K of the General Annexes, for example to access specific expertise, or to further build up and structure the interdisciplinary research and innovation ecosystems around the topic addressed by the proposal.

[3] This topic is aligned with the Commission communication SWD(2014) 211 'Towards a circular economy: a zero waste programme for Europe' and its annex, which describes specific contributions expected from FET.

Expected Impact:

- Establish a solid baseline of knowledge and skills for a future technology in the theme addressed.
- Goal oriented community structuring and true interdisciplinary collaboration.
- Emergence of an innovation ecosystem around a future technology in the theme addressed from outreach to and partnership with high potential actors in research and innovation.

Type of instrument(s): Research and Innovation Actions. The Commission considers that proposals with duration up to 5 years and requesting a contribution from the EU of between EUR 4 and 10 million would allow this specific challenge to be addressed appropriately.

Budget per type of instrument: 80MEuro from 2016 budget, with a maximum of 20MEuro for each of the areas 1 and 4, and a maximum of 30Meuro for each of the areas 2 and 3.

The conditions related to this topic are provided at the end of this call and in the General Annexes.

FET 2.2 – 2016: FET ERANET Cofund in Quantum Technologies

Specific Challenge: research on quantum technologies in Europe is currently funded through several targeted initiatives at European, national and regional level. The aim is to foster synergy between these initiatives in the area of quantum technologies in order to create collaborations among the best groups in Europe and fostering broader partnerships around them to spread excellence and to broaden the European footprint of this emerging technology area.

Scope: Proposals should coordinate national and regional programmes for research in the area of quantum technologies by implementing a transnational call with EU cofounding resulting in grants to third parties. This call shall address the following topics:

- New principles, experiments, technologies, devices and systems that exploit quantum phenomena like entanglement and superposition to achieve new of radically enhanced functionalities.
- Demonstration and critical assessment of these advancements in comparison to classical or other quantum-based technological options.
- Exploration of advanced quantum enabled applications in areas of scientific, industrial or societal interest, linked to a critical assessment of feasibility beyond the technical (e.g., in terms of innovation potential, acceptability and industrial/societal take-up).

Proposers are encouraged to implement other joint activities related to the coordination of public research and innovation programmes in quantum technologies, such as transnational networking, training, technology transfer and additional joint calls without EU co-funding.

Expected Impact

- Closer coordination and greater mobilisation and pooling of resources between regional, national and EU research programmes in the area of quantum technologies.
- Increased transnational collaboration on quantum technologies, especially on topics that are complementary to the EU workprogrammes in this area.
- Spreading of excellence on quantum technologies across Europe.
- Establishment and alignment of national and regional research and innovation plans and initiatives in the area of quantum technologies.
- Identification of promising directions for future research programming through a comprehensive overview on multiple lines of development across Europe.
- Increased awareness of national and regional research and innovation interests, synergies and complementarities in the area of quantum technologies and their applications.

Instrument(s): ERANET Cofund

Budget per type of instrument(s): 10Meuro from 2016 budget

The conditions related to this topic are provided at the end of this call and in the General Annexes.

Call FET Proactive: High Performance Computing

The FET-Proactive call on HPC aims at the next steps for leveraging the existing European strengths for building the next generation of extreme performance computing and taking advantage of the new opportunities created from the transition from peta to exascale computing. The ultimate goal is to achieve world-class extreme scale computing capabilities in platforms, technologies and applications.

The call complements the other building blocks under the e-Infrastructures and LEIT-ICT parts of Horizon 2020 of the European HPC strategy. The implementation of this HPC strategy in Horizon 2020 combines three elements: (a) developing the next generation of HPC towards exascale; (b) providing access to the best supercomputing facilities and services; and (c) achieving excellence in HPC applications. The Public Private Partnership (PPP) with the European Technology Platform in HPC (ETP4HPC), which started on 1 January 2014, provides the framework for the implementation of elements (a) and (c) of the HPC strategy, based on the Strategy Research Agenda (SRA) of the ETP4HPC[4].

FET 3.1 - 2016 FETHPC-1: Co-design of HPC systems and applications

Specific Challenge: Achieve world-class extreme scale, power-efficient and highly resilient HPC platforms through a strong co-design approach driven by ambitious applications and in close cooperation with the scientific disciplines and stakeholders concerned; achieve the full range of technological capabilities needed for delivering a broad spectrum of extreme scale HPC systems. The designs of these systems must respond to critical demands of energy efficiency, scale, resilience, programmability and support for various classes of applications including extreme-data applications.

Scope: proposals with innovative and ground-breaking approaches to system architectures targeting extreme scale, power-efficient and highly resilient platforms with emphasis on balanced compute and data access characteristics. Special attention should be given to extreme data processing requirements. Proposals should have a strong co-design approach driven by ambitious applications and in close cooperation with the scientific disciplines and stakeholders concerned. Proposals should show how their proposed solution improves energy efficiency and demonstrate the reduced energy-to-solution for the selected applications. Possible strategies for improving energy efficiency may include: reducing PUE (Power Usage Effectiveness), designing of cost-efficient approaches to the reuse of thermal energy, reducing the amount of energy spent for communication and data movement. Proposals should address the problem of maintaining reliability, coping with run-time errors and enabling stable

[4] See http://www.etp4hpc.eu/strategy/strategic-research-agenda/

operation of an HPC system that is able of extreme scaling; this issue may be addressed through holistic detection/recover approaches covering and orchestrating all layers of the HPC stack as well as significant advancements in fault prediction algorithms and smarter tools to prevent faults. Proposals should provide analytical or simulation models that allow to extrapolate the sustained performance on the given architecture for HPC systems. The target system architectures must scale to at least 100 PFlops and, for compute-centric workloads, a target of 15MW for 250 PFlops peak performance in 2019 is suggested. Proposals should explain how these scalability and energy-efficiency targets are achieved for the considered applications. APIs and interfaces between applications and underlying middleware, run-time and operating systems, i.e. all application-aspects impacting the underlying system design are included in this topic. Proposals should be able to demonstrate their achievements in integrated pre-exascale prototypes.

Expected Impact:

- Contribution to the realisation of the ETP4HPC Strategic Research Agenda, thus strengthened European research and industrial leadership in HPC technologies.
- Proof-of-concept through integrated pre-exascale prototypes for future exascale-class HPC systems and optimal co-design driven by ambitious applications.
- Covering important segments of the broader and/or emerging HPC markets, especially extreme-scale HPC systems.
- Impact on standards bodies and other relevant international research programmes and frameworks.

Type of instrument(s): Research and Innovation Actions. The Commission considers that proposals requesting a contribution between EUR 10 and 20 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Budget per type of instrument: 41 million from 2016

FET 3.2 FETHPC-2 2017: Transition to Exascale Computing

Specific Challenge: Take advantage of the full capabilities of exascale computing, in particular through high-productivity programming environments, system software and management, exascale I/O and storage in the presence of multiple tiers of data storage, supercomputing for extreme data and emerging HPC use modes, mathematics and algorithms for extreme scale HPC systems for existing or visionary applications, including data-intensive and extreme data applications in scientific areas such as physics, chemistry, biology, life sciences, materials, climate, geosciences, etc.

Scope: proposals should address one of the following subtopics

a) **High productivity programming environments for exascale**: Proposals should have as target to simplify application software development for large- and extreme-scale systems using increased intelligence throughout the programming environment. Runtime systems should play a key role managing data transfers, locality, inherent data sub-structures and their mapping to memory, including support for heterogeneous and reconfigurable systems as well as dealing with inter-application dynamic load balancing and malleability, adapting to changes in the number of processors. Unified performance tools are required supporting HPC, embedded and extreme data workloads, on diverse target systems. APIs, runtime systems and the underlying libraries must support auto-tuning for performance and energy optimisation. Automated support for debugging and anomaly detection is also included under this subtopic. To provide simplified development and to ensure the maintainability of domain-specific languages (DSLs), DSL frameworks are required which target a general-purpose stable programming model and runtime. Since large future systems will require the use of multiple programming models or APIs, an important aspect is interoperability and standardisation of programming model, API and runtime as well as the composability of programming models (the capability of building new programming models out of existing programming model elements)

b) **Exascale system software and management**: Proposals should advance the state of the art in system software and management for node architectures that will be drastically more complex and their resource topology and heterogeneity will require OS and runtime enhancement, such as data aware scheduling. In the area of hardware abstraction, proposals should address run time handling of all types of resources (cores, bandwidth, logical and physical memory or storage) and controls, e.g. for optimised data coherency, consistency and data flow. For applications, proposals should provide new multi-criteria resource allocation capabilities and interaction during tasks execution for resilience, interactivity, power and efficiency purposes. To cope with the exploding amount of data, the sequential analysis process (capture, store, analyse) is not sufficient; proposals should explore on-the-fly analysis methods offering reactivity, compute efficiency and availability. Graphical simulation interaction will require new real-time features; configuration and deployment tools will have to evolve to take into account the composability of software execution environments.

c) **Exascale I/O and storage in the presence of multiple tiers of data storage**: proposals should address exascale I/O systems expected to have multiple tiers of data storage technologies, including non-volatile memory. Fine grain data access prioritisation of processes and applications sharing data in these tiers is one of the goals as well as prioritisation applied to file/object creates/deletes. Runtime layers should combine data replication with data layout transformations relevant for HPC, in order to meet the needs for improved performance and resiliency. It is also desirable for the I/O subsystem to adaptively provide optimal performance or reliability especially in the presence of millions of processes simultaneously doing I/O. It is critical that programming system interoperability and standardised APIs are achieved. On the fly data management supporting data processing,

taking into account multi-tiered storage and involving real time in situ/in transit processing should be addressed.

d) **Supercomputing for Extreme Data and emerging HPC use modes**: HPC architectures for real-time and in-situ data analytics are required to support the processing of large-scale and high velocity real-time data (e.g. sensor data, Internet of Things) together with large volumes of stored data (e.g. climate simulations, predictive models, etc.). The approaches should include support for real-time in-memory analysis of different data structures, direct processing of compressed data and appropriate benchmarking method for performance analysis. Enablement of data-centric HPC real-time interactive 3-D visualisation of large-scale data to allow users to explore large information spaces in 3-D and perform on-demand data analysis in real-time (e.g. large scale queries or analytics) should be addressed.. Interactive supercomputing is required to execute complex workflows for urgent decision making in the field of critical clinical diagnostics, natural risks or spread of diseases; this implies adapting operational procedures of HPC infrastructures, developing efficient co-scheduling techniques or improving checkpoint/restart and extreme data management

e) **Mathematics and algorithms for extreme scale HPC systems and applications working with extreme data:** Specific issues are quantification of uncertainties and noise, multi-scale, multi-physics and extreme data. Mathematical methods, numerical analysis, algorithms and software engineering for extreme parallelism should be addressed. Novel and disruptive algorithmic strategies should be explored to minimize data movement as well as the number of communication and synchronization instances in extreme computing. Parallel-in-time methods may be investigated to boost parallelism of simulation codes across a wide range of application domains. Taking into account data-related uncertainties is essential for the acceptance of numerical simulation in decision making; a unified European VVUQ (Verification Validation and Uncertainty Quantification) package for Exascale computing should be provided by improving methodologies and solving problems limiting usability for very large computations on many-core configurations; access to the VVUQ techniques for the HPC community should be facilitated by providing software that is ready for deployment on supercomputers.

Expected Impact:

- Contribution to the realisation of the ETP4HPC Strategic Research Agenda, thus strengthened European research and industrial leadership in HPC technologies.
- Successful transition to exascale computing for the addressed specific element of the HPC stack.
- Covering important segments of the broader and/or emerging HPC markets, especially extreme-computing and extreme-data HPC systems.
- Impact on standards bodies and other relevant international research programmes and frameworks.
- European excellence in mathematics and algorithms for extreme parallelism and extreme data applications to boost research and innovation in scientific areas such as physics, chemistry, biology, life sciences, materials, climate, geosciences, etc.

Type of instrument(s): Research and Innovation Actions. The Commission considers that proposals requesting a contribution from the EU between EUR 2 and 4 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Budget per type of instrument: 40 million from 2017

FET 3.2 – 2017 FETHPC-3: Exascale HPC ecosystem development

Specific challenge: to develop a sustainable European exascale HPC Ecosystem

Scope: proposals shall address one of the two following topics:

a) Coordination of the Exascale HPC strategy and International Collaboration: Proposals must include activities for promoting a joint community structuring and synchronisation; the further development and update of the Strategic Research Agenda for High Performance Computing as well as the application and applied mathematics exascale roadmaps; prepare the ground for targeted international research collaboration on specific aspects of the exascale challenges. Proposed actions should also seek to create synergies with other HPC related activities under H2020, in particular concerning the underlying basic technologies that are required for exascale computing (e.g. *LEIT/Advanced Computing*, *LEIT/Photonics*, and *ECSEL* (Electronic Components and Systems for European Leadership)); and concerning the relevant research in applications which progress critically rely on cutting-edge HPC systems (*LEIT/Big-Data*, *LEIT/Cloud* area as well as relevant research in applications emerging from the *H2020 Societal Challenges* in domains such as health (e.g. VPH initiative), genomics, climate change, energy, mobility and smart cities).

b) Excellence in Exascale Computing Systems: The focus should be in boosting European HPC academic research excellence in future exascale-class computing cutting across all levels – hardware, architectures, programming, applications – and including specific actions to better structure the European academic HPC research, create stronger links with HPC providers and HPC users, attract venture capital, promote entrepreneurship and foster industry take-up.

Expected Impact:

- Strengthened European research and industrial leadership in the supply, operation and use of HPC systems.
- Contribution to the realisation of the ETP4HPC Strategic Research Agenda.

- Development of a competitive European ecosystem for building and exploiting a wide range of next-generation extreme performance computing systems.
- Structuring the efforts of stakeholders for implementing the European HPC strategy;
- Reinforced cooperation in international endeavours on HPC software and systems towards exascale.
- European Excellence in Exascale Computing systems.

Type of instrument(s): Coordination and Support Actions

Budget per type of instrument: 4 MEuro from 2017 budget

Call FET FLAGSHIPS – tackling grand interdisciplinary science and technology challenges

Flagships are science-driven, large-scale, multidisciplinary research initiatives oriented towards a unifying goal, aiming at transformational impacts on science and technology and substantial benefits for European competitiveness and society. The goals of such initiatives are visionary and highly ambitious in terms of scientific challenges, resources and coordinated efforts. They require cooperation among a range of disciplines, communities and national, regional and European programmes. The implementation model of the Flagships and their governance structure are described in the Commission Staff Working Document on FET Flagships[5].

Two Flagships, Graphene and the Human Brain Project, have been launched in 2013. A Framework Partnership Agreement (FPA) has been established for each of them, creating a stable and structured partnership between the Commission and research organisations that are committed to implement the Flagships. This work programme aims to launch actions to advance the two Flagships on the basis of these FPAs, following an initial Specific Grant Agreement (SGA) and other actions launched under previous work programmes.

FET 4.1 FETFLAG-1 2016: Partnering environment for FET Flagships

Specific challenge: To support funding and coordination of partnering projects (PPs) of the two Flagships.

PPs are regionally or nationally funded projects or projects supported by private funds that are addressing areas relevant to the Flagships. They are an integral part of the Flagships and contribute to their objectives.

The aim is to bring together national funding agencies from Member States and Associated Countries to fund such PPs, as well as supporting these and other PPs in their networking, coordination and participation in Flagship activities.

Scope:

a. ERA-NET Cofund action

[5] SWD(2014) 283 final of 16.09. 2014

One action that coordinates national and regional research programmes to fund PPs of the two Flagships through a transnational call for proposals with EU co-funding, possibly followed by further calls for proposals without EU co-funding. The action may also organise additional joint activities between the participating funding agencies in support of the two Flagships.

b. Coordination and Support action

One action will be funded which will support all of the following points, for both Flagships:

- the participation of PPs in meetings, workshops or other relevant activities organised by the Core Project of each Flagship;
- the participation of PPs in the governance activities of each of the Flagships;
- the networking and coordination of the PPs for helping them contribute to the research roadmaps of each Flagship and for disseminating their activities to promote Flagships at the regional/national level.

Proposals for such an action need to demonstrate how they add value beyond the activities already foreseen in the Flagships to liaise with PPs.

The action should be driven by (one or more) stakeholders representing relevant scientific communities.

Expected impact:

a. ERA-NET Cofund action

Closer coordination and greater mobilisation and pooling of resources between regional, national and EU research programmes for realising the research goals of the FET Flagships;

b. Coordination and Support Action

Creating mutual benefit between the PPs and their Core Project, enhancing the impact of the Flagships on national and regional research programmes and fostering the role of PPs in the governance of the Flagships.

Types of instrument(s):

a. ERA-NET Cofund Action.

b. Coordination and Support Action

Budget per type of instrument: EUR 8 million for (a) and 1 million for (b) from the 2016 budget

The conditions related to this topic are provided at the end of this call and in the General Annexes.

Other actions

FET Flagship Core Projects

a – Graphene FET Flagship Core Project

Within the Graphene Framework Partnership Agreement (FPA) awarded under topic FETFLAG 1 - 2014 of the Call FET Flagships, the selected consortium will be invited to submit a proposal for a second Specific Grant Agreement (SGA) that will implement the next two years (indicative) of the action plan defined in the FPA.

The proposal should adhere to the programme of activities as envisioned in the FPA. It should address key parts of the FPA research roadmap while taking into account, whenever relevant, the changing state of the art throughout the world.

The proposal should describe how the coordination and management of the overall Flagship initiative as described in the FPA is implemented. The coordinating role must include in particular the concrete actions needed to ensure the overall continuity and coherence in the management of the Flagship initiative, such as (i) the governance of the Flagship initiative as a whole, (ii) updating the research roadmap and its innovation branches, and (iii) the collaboration with other research initiatives or programmes at regional, national, European or international level.

The proposal should focus on those areas that have the greatest innovation potential and impact on economy and society. This may require refocusing the Flagship resources accordingly. Any modification to the FPA selected Consortium partners should be sufficiently motivated and based on the highest standards of scientific and technological excellence and on open and transparent criteria.

The proposal should detail activities in areas such as human capital, education and training, dissemination, ethics and societal aspects.

This action allows for the provision of financial support to third parties in line with the conditions set out in Part K of the General Annexes.

Expected impact**:** Contribution to the targeted impacts defined in the action plan of the FPA.

Type of instrument(s): Research and Innovation Action funded through a Specific Grant Agreement under the Graphene Framework Partnership Agreement.

Indicative timetable: Second quarter of 2017

Indicative budget: EUR 88 million from the 2017 budget

The criteria, scoring and threshold are described in part H of the General Annexes to the work programme.

b – Human Brain Project FET Flagship Core Project

Within the Human Brain Project (HBP) Framework Partnership Agreement (FPA) awarded under topic FETFLAG 1 - 2014 of the call FET Flagships, the selected consortium will be invited to submit a proposal for a second specific Grant Agreement (SGA) that will implement the next two years (indicative) of the action plan defined in the FPA.

The proposal should adhere to the programme of activities as envisioned in the FPA. It should describe how the activities carried out during the first SGA will be built upon, maintaining a multi-disciplinarily approach and involving the relevant scientific communities in neuroscience, medicine and computing. It should take into account, whenever relevant, progress made by other large brain research initiatives.

The proposal should explain how the project will involve the related scientific and medical communities, including a large number of end-users, in the development and validation of the HBP ICT platforms and ensure their wide adoption and use. It should also explain how the HBP partners will trigger concrete innovation activities by liaising with industry and other relevant stakeholders.

The proposal should describe how the coordination and management of the overall Flagship initiative as described in the FPA is implemented. The coordinating role must include in particular the concrete actions needed to ensure the overall continuity and coherence in the management of the Flagship initiative, such as (i) the governance of the Flagship initiative as a whole, (ii) updating the research roadmap and its innovation branches, and (iii) the collaboration with other research initiatives or programmes at regional, national, European or international level.

The proposal should detail activities in areas such as human capital, education and training, dissemination, ethics and societal aspects.

This action allows for the provision of financial support to third parties in line with the conditions set out in Part K of the General Annexes.

Impact: Contribution to the targeted impacts defined in the action plan of the HBP FPA.

Type of instrument(s): Research and Innovation Action funded through a specific grant agreement under the HBP FPA.

Indicative timetable: Second quarter of 2017

Indicative budget: EUR 88 million from the 2017 budget

The criteria, scoring and threshold are described in part H of the General Annexes to the work programme.